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Agricultural Memorandum No 743

Potential and Effective Transpiration in the Growing Season - Statistical Relationships

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Following the lines of Ag Mem 742, the areal averages of Potential Transpiration (PTgs) and Effective Transpiration (ETgs) in the growing season were statistically analysed on a regional basis.

Table 1 shows the variation of PTgs with height for the several regions. This suggests that adjustments for height change could fit the following pattern.

	mm per 100m		mm per 100m
N.W. England	45–50	N.E. England	35–40
Wales	40–45	N. Midlands	25–30
S.W. England	45–50	S. Midlands	20–25
		E. & S.E. England	

Tables 2 and 3 show the regressions on annual PT (PTa) and annual air temperature (Ta) respectively. These suggest that the simplest estimate of the Potential Transpiration during the growing season can be obtained from

$$1.16\ PTa - 117 \qquad \text{(Correl. 0.99)}$$

Table 4 shows the variation of Effective Transpiration with height. Clearly when the lower level areas are deficient in rainfall, then there is an increase of ETgs with height as the increase of rainfall more than compensates with the decrease in PTgs. The reverse is true in the wetter western areas, as rainfall is likely to be more than adequate at higher levels and the dominating effect is decrease of PTgs with height.

It is therefore not sensible to attempt to specify a linear change of ETgs with height.

Tables 5 and 6 show variations of ETgs with PTa, Ta (annual average air temperature) and Ra (annual average rainfall). Although correlations are high, the nature of the formulae suggest mathematical fits rather than a logical relationship.

A more sensible formula was obtained by considering the variation of the ratio $100\ \frac{ETgs}{PTa}$, and dividing the country into areas below and above an annual rainfall of 1000 mm. The results are shown in Table 7.

This suggests that $\frac{ET}{PTa}$, expressed as a percentage increased by an (absolute not relative) amount of 4% per 100 mm increase in annual rainfall up to 1000 mm. Beyond that figure the increase is about 1% per 100 mm.

Better fits are obtained with the use of the Potential Transpiration (PTs) and Rainfall values for the April-September period (Rs).

The formulae for stations with Rs below and above 430 mm are given in Table 8.

Table 1

Variation of Growing Season P.T. with height

	Correl.	
N.E. England	(-0.83)	447 - 0.36h
N.W. England	(-0.95)	493 - 0.49h
N. Midlands	(-0.85)	488 - 0.27h
S. Midlands	(-0.74)	499 - 0.23h
East & S.E. England		indefinable
S.W. England	(-0.96)	551 - 0.51h
Wales	(-0.98)	518 - 0.39h

Table 2

Variation of Growing Season PT with mean annual PT (PTa)

	Correl.	
N.E. England	(0.99)	1.24 PTa - 157
N.W. England	(0.99)	1.08 PTa - 80
N. Midlands	(0.98)	1.10 PTa - 91
S. Midlands	(0.93)	1.04 PTa - 56
E. & S.E. England	(0.98)	1.11 PTa - 96
S.W. England	(0.99)	1.15 PTa - 102
Wales	(0.99)	1.24 PTa - 157
England & Wales	(0.99)	1.16 PTa - 117

Table 3

Variation in Growing Season PT with mean annual air temperature (Ta)

N.E. England	(0.98)	55.8 Ta - 67.5
N.W. England	(0.99)	68.4 Ta - 169.5
N. Midlands	(0.86)	45.2 Ta - 46.8
S. Midlands	(0.81)	26.8 Ta + 219
E & S.E. England	(0.92)	52.5 Ta - 15.3
S.W. England	(0.94)	60Ta - 109.9
Wales	(0.99)	57.1 Ta - 69.9
England & Wales	(0.97)	61.3 Ta - 106.8

Table 4

Variation of Effective Transpiration with height

	Correl.	
N.E. England	(-0.53)	354.7 - 0.11h
N.W. England	(-0.95)	419.7 - 0.29h
N. Midlands	(+0.81)	334.2 + 0.27h
S. Midlands	not significant	
E. & S.E. England	(+0.37)	347.2 + 0.29h
S.W. England	(-0.45)	451.4 - 0.16h
Wales	(-0.87)	456.7 - 0.24h

Table 5

Variation of Effective Transpiration with annual PT and annual rainfall averages

N.E. England	(0.86)	1.96 + 0.67 PTa + 0.047 Ra
N.W. England	(0.97)	81.4 + 0.63 PTa + 0.003 Ra
N. Midlands	(0.96)	-133.7+ 0.65 PTa + 0.25 Ra
S. Midlands	(0.96)	148.4- 0.08 PTa + 0.38 Ra
E. & S.E. England	(0.97)	109.8+ 0.23 PTa + 0.19 Ra
S.W. England	(0.90)	-356.4+ 1.23 PTa + 0.14 Ra
Wales	(0.98)	-135.2+ 1.03 PTa + 0.04 Ra
England & Wales	(0.86)	-38.7 + 0.67 PTa + 0.09 Ra

Table 6

Variation of Effective Transpiration with annual air Temperature and annual rainfall averages

N.E. England	(0.88)	-38.2 + 37.5 Ta + 0.083 Ra
N.W. England	(0.97)	-207.7 + 59.7 Ta + 0.065 Ra
N. Midlands	(0.95)	11.3 + 21.4 Ta + 0.23 Ra
S. Midlands	(0.96)	63.7 + 4.9 Ta + 0.38 Ra
E. & S.E. England	(0.97)	135.4 + 10.6 Ta + 0.18 Ra
S.W. England	(0.98)	-214.4 + 54.6 Ta + 0.09 Ra
Wales	(0.98)	-114.4 + 51.0 Ta + 0.05 Ra
England & Wales	(0.86)	- 49.8 + 38.1 Ta + 0.086 Ra

Table 7

Ratio of Effective Transpiration and annual PT

(a) For areas with annual rainfalls below 1000 mm

N.E., N.W. and Midland England

$$100 \times \frac{ET}{PTa} = 0.042\ Ra + 44.8 \qquad \text{Correl. } 0.89$$

East and Southern England

$$100 \times \frac{ET}{PTa} = 0.038\ Ra + 47.9 \qquad \text{Correl. } 0.95$$

(b) For areas with annual rainfalls above 1000 mm

$$100 \times \frac{ET}{PTa} = 0.008\ Ra + 1.83\ Ta + 59.$$

Correl. 0.93

Table 8

Variation of Effective Transpiration with Summer Rainfall and annual air temperature averages

(a) For average summer rainfall (Rs) < 430 mm, where PTs = summer transpiration average

$$100 \frac{ET}{PTs} = 0.145\ Rs + 33.3 \qquad \text{Correl. } 0.92$$

$$ET = 0.55\ Rs + 29.5\ Ta - 100.6 \qquad \text{Correl. } 0.97, \text{ Partials } 0.96 \text{ \& } 0.94$$

(b) for Rs > 430 mm.

$$100 \frac{ET}{PTs} = 0.03\ Rs + 5.17\ Ta + 36.5 \qquad \text{Correl. } 0.96, \text{ Partials } 0.89 \text{ \& } 0.96$$

$$ET = 0.13\ Rs + 50.8\ Ta - 123.8 \qquad \text{Correl. } 0.97, \text{ Partials } 0.73 \text{ \& } 0.96$$

Any comments or suggestions on this paper should be referred to the author.

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July 1975.